FLAT PLATE HEAT TRANSFER DEVICE

TECHNICAL FIELD

The present invention relates to a flat plate heat transfer device capable of transferring heat by means of a working fluid circulating mechanism using evaporation and condensation without applying a separate mechanical energy, and more particularly to an improved flat plate heat transfer device capable of having a thinner structure and preventing transformation caused by an external impact.

BACKGROUND ART

In recent, an electronic equipment such as notebook or PDA becomes smaller and thinner along with the development of integration technique. In addition, together with the increased demands for high response of an electronic equipment and improvement of functions, energy consumption is also tending increased. Accordingly, much heat is generated from electronic parts in the electronic equipment while the equipment is operated, so various flat plate heat transfer devices are used to emit the heat outside.

A traditional example of the conventional flat plate heat transfer device is a heat pipe in which a flat metal case is decompressed to a vacuum and then a working fluid is injected and sealed therein.

The heat pipe is installed so that it is partially in contact with an electronic part generating heat (or, a heat source). In this case, a working fluid near the heat source is heated and evaporated, and is then dispersed to a region with a relatively lower temperature. And then, the vapor is condensed into a liquid again with emitting heat outside, and then returns to its initial position. By means of such working fluid circulating mechanism conducted in the flat metal case, the heat generated in the heat

source is emitted outside, and the temperature of the electronic part may be kept in a suitable level accordingly.

FIG. 1 shows that a conventional flat plate heat transfer device 10 is installed between a heat source 20 and a heatsink 30 to transfer heat from the heat source 20 to the heatsink 30.

Referring to FIG. 1, the conventional flat plate heat transfer device 10 has a metal case 50 whose inner space 40 is filled by a working fluid. On an inner side of the metal case 50, a wick structure 60 is formed for providing an efficient working fluid circulating mechanism.

The heat generated in the heat source 20 is transferred to the wick structure 60 in the flat plate heat transfer device 10 contacted with the heat source 20. Then, the working fluid contained at the wick structure 60 (that is acting as ‘an evaporating part’) approximately right above the heat source 20 is evaporated and dispersed in all directions through the inner space 40, and the working fluid is then condensed again after emitting heat at the wick structure 60 (that is acting as ‘a condensing part’) approximately right below the heatsink 30. The heat emitted in the condensation step is transferred to the heatsink 30, and then discharged out by means of the forced convection by a fan 70.

In order to realize the aforementioned heat transfer mechanism in the flat plate heat transfer device 10, a liquid should absorb heat in the evaporating part right above the heat source 20 to be evaporated, and then move to the condensing part again. Thus, the flat plate heat transfer device 10 should basically has a sufficient space therein where the vapor may be dispersed to the condensing part. If there is no sufficient space for the working fluid to be dispersed from the evaporating part to the condensing part, the heat transfer mechanism using evaporation and condensation of the working fluid may be not appropriately realized, thereby deteriorating the performance of the heat transfer device.

Meanwhile, as the thickness of the electronic equipment recently becomes smaller in recent years, a small thickness is also required for the flat plate heat transfer device. However, since the conventional flat plate heat transfer device 10 keeps its inside vacuous (or, decompressed) and does not adopt a mechanical structure capable of enduring an external impact, the metal case 50 is apt to be crushed by a trivial impact while the device is manufactured or handled, which resultantly transforms a vapor dispersion channel, thereby deteriorating a heat transfer characteristic of the product. Accordingly, the conventional flat plate heat transfer device 10 has a limitation in satisfying the current demands for a thinner structure.

DISCLOSURE OF INVENTION

The present invention is designed to solve the problems of the prior art, and therefore it is an object of the present invention to provide a flat plate heat transfer device with an improved inner structure, which is capable of becoming thinner with keeping the heat transfer mechanism using evaporation and condensation of a working fluid as it was, and preventing the device from being transformed by an impact possibly applied while the device is manufactured or handled.

In order to accomplish the above object, the present invention provides a flat plate heat transfer device, which includes a thermal-conductive flat case installed between a heat source and a heat emitting unit and containing a working fluid which is evaporated with absorbing heat from the heat source and is condensed with emitting heat to the heat emitting unit; and one layer of mesh installed in the flat case and configured so that wires are woven to be alternately crossed up and down, wherein a dispersion channel of a vapor is formed along a surface of the wire from a cross point of the mesh near the heat source, and a flow channel of a liquid is formed by means of a capillary phenomenon

along a length direction of the wire from a mesh lattice near the heat emitting unit to a mesh lattice near the heat source.

Preferably, the mesh is a screen mesh with a mesh number of 10 to 60.

It is also preferable that the mesh is woven by wires with a diameter of 0.12 mm to 0.4 mm.

In addition, the thermal-conductive flat case preferably has a height of 0.3 mm to 1.0 mm.

In case the mesh is a screen mesh, it is preferred that a length direction of a lengthwise wire among the wires is identical to a direction in which heat transfer is conducted.

In case the thermal-conductive flat case is made of electrolytic copper foil, an uneven surface of the electrolytic copper foil is preferably configured as an inner side of the flat case.

The mesh is made of one selected from the group consisting of metal, polymer, plastic and glass fiber. Here, the metal may be selected from the group consisting of copper, aluminum, stainless steel, molybdenum, and their alloys.

The flat case is made of one selected from the group consisting of metal, conductive polymer, metal coated with conductive polymer, and conductive plastic. Here, the metal may be selected from the group consisting of copper, aluminum, stainless steel, molybdenum, and their alloys.

The flat case may be sealed using a manner selected from the group consisting of laser welding, plasma welding, TIG (Tungsten Inert Gas) welding, ultrasonic welding, brazing, soldering, and thermo-compression lamination.

The working fluid may be selected from the group consisting of water, methanol, ethanol, acetone, ammonia, CFC working fluid, HCFC working fluid, HFC working fluid,

and their mixture.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and aspects of the present invention will become apparent from the following description of embodiments with reference to the accompanying drawing in which:

FIG. 1 is a sectional view showing a conventional flat plate heat transfer device;

FIG. 2 is a sectional view showing a flat plate heat transfer device according to an embodiment of the present invention;

FIG. 3 is a plane view showing a lattice of a woven mesh mounted in a flat case of the flat plate heat transfer device according to an embodiment of the present invention;

FIG. 4 is a sectional view showing the lattice, taken along an A-A' line of FIG. 3;

FIGs. 5 and 6 are partial sectional view and partial plane view of the flat plate heat transfer device, showing that a liquid membrane is formed on the mesh while the flat plate heat transfer device of the present invention is operated, respectively;

FIGs. 7 to 9 are perspective views showing various appearances of the flat plate heat transfer device according to the present invention; and

FIGs. 10 to 12 are sectional views showing various examples of a case used in the flat plate heat transfer device according to the present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

Hereinafter, embodiments are described for specifying the present invention, and detailed description will be provided with reference to the accompanying drawings for better understanding of the invention. However, the embodiments of the present invention may be modified in various ways, and it should not be interpreted that the

scope of the invention is limited to the embodiments described below. The embodiments of the invention are provided just for clearer and more definite illustration to those having ordinary skill in the art. In the drawings, the same reference numeral designates the same element.

A flat plate heat transfer device 100 according to a preferred embodiment of the present invention includes a flat case 130 installed between a heat source 110 and a heat emitting unit 120 such as a heatsink, one mesh 140 inserted into the case 130, and a working fluid injected into the case 130 to act as a medium for transferring heat from the heat source 110 to the heat emitting unit 120, as shown in FIG. 2.

In the flat plate heat transfer device 100, the working fluid exiting near a position right above the heat source 100 (hereinafter, referred to as 'a evaporating part') is evaporated into a vapor and then dispersed through vapor dispersion channels, described later, provided by the mesh 140. And then, the vapor is condensed into a liquid at a position with a relatively lower temperature than the heat source 110 (hereinafter, referred to as 'a condensing part'), for example, near a position right below the heat emitting unit 120. Subsequently, the condensed liquid makes a full revolution with flowing toward the position right above the heat source 110 through liquid flowing channels, described later, formed by the capillary phenomenon caused by the mesh 140. In this process, the working fluid takes heat from the heat source 110 and then transfers the heat to the heat emitting unit 120. In addition, the heat transferred to the heat emitting unit 120 is discharged outward by means of the forced convection by the fan 150, and the temperature of the heat source 110 is thus kept within a suitable level. In an ideal case, the working fluid heat transfer mechanism using evaporation and condensation is continued until the temperature of the heat source 110 becomes substantially equal to the temperature of the heat emitting unit 120.

The flat case 130 has an inner space decompressed into a vacuum, and the flat case 130 is made of a metal with excellent heat conductivity, a conductive polymer, a metal coated with a conductive polymer, or a heat-conductive plastic so that it may easily absorb heat from the heat source 110 and also easily emit heat to the heat emitting unit 120 again. Preferably, the metal is one of copper, aluminum, stainless steel and molybdenum, or their alloy. In particular, in case the flat case 130 is made of an electrolytic copper foil with unevenness on one surface, the uneven surface is preferably oriented toward an inner surface of the flat case 130. In this case, the working fluid may return more smoothly by means of the capillary phenomenon, thereby improving efficiency of the flat plate heat transfer device 100. The flat case 130 preferably has a thickness of 0.01 mm to 1.0 mm, considering a heat conduction characteristic and a mechanical strength thereof.

The mesh 140 is provided between the upper and lower plates of the flat case 130, and configured so that wires 140a and 140b are woven to be alternately crossed up and down. The mesh 140 may be made of any of metal, polymer, glass fiber and plastic. Preferably, the metal is one of copper, aluminum, stainless steel and molybdenum, or their alloy. The mesh 140 may be made with various shapes in correspondence to the shape of the flat case 130 of the flat plate heat transfer device 100.

The mesh 140 is a woven mesh in which widthwise wires 140a and lengthwise wires 140b are woven to be alternatively crossed as shown in FIGs. 3 and 4. A width (a) of an opening existing in a unit lattice of the mesh 140 is generally expressed like the following equation 1.

Equation 1

$$a = (1 - Nd) / N$$

Here, d is a diameter (inch) of the mesh wire, and N is a lattice number of the mesh 140 existing in one inch. For example, if N is 100 in a square mesh 140, 100 mesh lattices are present in one-inch length.

In the present invention, the mesh 140 acts as a means for providing a vapor dispersion channel (I) in which a vapor evaporated by the heat source 110 may flow. Specifically, a space 160 generated by crossing of the widthwise wires 140a and the lengthwise wires 140b exists in the mesh 140 as shown in FIG. 4, and this space 160 functions as the vapor dispersion channel (I) where the vapor may be dispersed. Here, the lengthwise wires 140b are defined as mesh wires which are arranged in rows in a length direction when being woven, while the widthwise wires 140a are defined as mesh wires which are arranged perpendicular to the lengthwise wires 140b.

A geometric area (A) of the vapor dispersion channel (I) is calculated according to the following equation 2.

Equation 2

$$A = (a + d)d - \pi d^2/4$$

Referring to the equation 2, the geometric area of the vapor dispersion channel (I) is increased as the mesh number (N) is decreased and the diameter (d) of the mesh wire is increased.

In a lattice of the mesh 140, there are four vapor dispersion channels (I), owned in common with adjacent lattices, so the working fluid is smoothly dispersed in four directions on the basis of the center (O) of the mesh lattice as shown in FIG. 3 (see ↔ arrows).

In case the mesh 140 is a screen mesh, a slope of the lengthwise wire 140b arranged perpendicular to the widthwise wire 140a, looked in a length direction of the widthwise wire 140a (not shown), is more inclined than a slope of the widthwise wire 140a arranged perpendicular to the lengthwise wire 140b, looked in a length direction of the lengthwise wire 140b (see FIG. 4). Thus, the vapor may more smoothly flow in the length direction of the lengthwise wire 140b of the mesh 140 than in the length direction of the widthwise wire 140a, thereby giving better heat transfer efficiency in the length direction of the lengthwise wire 140b. Thus, in case the mesh 140 is a screen mesh, it is preferred that a heat transfer direction is coincided with the length direction of the lengthwise wire 140b when the flat plate heat transfer device 100 is installed and operated.

Meanwhile, when the flat plate heat transfer device 100 according to the present invention is actually operated, the mesh 140 comes in contact with a liquid with being interfaced with the upper and lower plates of the flat case 130 as shown in FIG. 5. Thus, a liquid membrane 180 is formed at a wedge-shaped gap 170 of the vapor dispersion channel (I) existing in the mesh 140 by means of the liquid.

The liquid membrane 180 is formed at all crossing points of the mesh wire as shown in FIG. 6. If suitably controlling a width (a) of the mesh lattice and/or a diameter (d) of the mesh wire among parameters of the mesh 140, the liquid membranes 180 formed at the wire-crossing points are connected to each other, thereby generating the capillary phenomenon. Thus, if the working fluid received with a shape of the liquid membrane 180 in the mesh lattice existing in the evaporating part is evaporated, a working fluid received in an adjacent mesh lattice is flowed to the mesh lattice of the evaporating part as much as the evaporated amount along the length direction of the mesh wire by means of the capillary phenomenon.

That is to say, in the flat plate heat transfer device 100 according to the present invention, the evaporating part is lack of liquid since the working fluid is continuously evaporated and dispersed, while the condensing part has excessive liquid since the working fluid is continuously condensed therein. However, the capillary phenomenon caused by the surface tension of the liquid membrane 180 formed in the mesh lattice induces the capillary phenomenon to make liquid flow from the condensing part to the evaporating part, so the working fluid is continuously supplemented in the evaporating part along the length of the mesh wire, thereby keeping the heat transfer mechanism using evaporation and condensation of the working fluid. That is to say, the flow channel of the liquid is formed along the length of the mesh wire.

However, if a mesh number (N) of the mesh 140 is too increased or a diameter (d) of the mesh wire is too decreased, the vapor dispersion channel (I) becomes completely blocked by means of the liquid due to the surface tension. In this case, the working fluid evaporated in the evaporating part cannot be dispersed into the condensing part through the vapor dispersion channel (I), thereby disturbing smooth heat transfer. Thus, the parameters of the mesh 140, which are a mesh number (N) and a diameter (d) of the mesh wire, should be suitably selected in consideration that the mesh 140 gives not only the vapor dispersion channel (I) but also a flow channel of the liquid due to the capillary phenomenon. Preferably, the mesh 140 has a mesh number of 10 to 60, and a diameter of the mesh wire is in the range of 0.12 mm to 0.4 mm.

According to the present invention, since there is used the mesh which gives the vapor dispersion channel and the liquid flow channel at the same time, the flat case 130 does not require a conventional wick structure on its inner surface. Thus, the flat plate heat transfer device 100 may have a thinner thickness up to 0.3 mm to 1 mm in correspondence to the omission of a wick structure. In addition, the flat plate heat

transfer device 100 may have an increased mechanical strength rather than a conventional one since the mesh 140 included in the flat plate heat transfer device 100 even plays a role of supporting the flat case 130.

The flat plate heat transfer device 100 according to the present invention may have various shapes such as a square, rectangular or T shape, as shown in FIGs. 7 to 9. In addition, the flat case 130 of the flat plate heat transfer device 100 may be configured as a combination of upper and lower cases 130a and 130b as shown in FIGs. 10 and 11 or as one case only as shown in FIG. 12.

The flat case 130 is finally sealed after a working fluid is filled therein with its inner space being decompressed into a vacuum level. The sealing is conducted using any of laser welding, plasma welding, TIG (Tungsten Inert Gas) welding, ultrasonic welding, brazing, soldering, and thermo-compression lamination.

The working fluid may be one of water, methanol, ethanol, acetone, ammonia, CFC working fluid, HCFC working fluid, and HFC working fluid, or their mixture.

<u>Experimental Example</u>

In order to evaluate the effects of the flat plate heat transfer device according to the present invention, inventors manufactured a flat plate heat transfer device with 40 mm, 70 mm and 0.65 mm in length, width and height. A flat case was composed by associating upper and lower cases separately as shown in FIG. 10, and they were made of a rolled copper foil with a thickness of 0.1 mm. A mesh included in the flat case was a copper screen mesh with a mesh number of 15, a diameter of the mesh wire of 0.20 mm, and a content of copper of 99% or above.

In order to make the flat plate heat transfer device to be used in this experiment, the screen mesh was positioned between the upper and lower cases so that each case is

faced with the screen mesh as shown in FIG. 10, and then the upper and lower cases are sealed using denatured acrylic binary bond manufactured by DENKA in Japan (Trademark: HARDLOC) with a working fluid injection hole left.

And then, before a working fluid is injected thereto, the inside of the flat case is decompressed to 1.0×10^{-7} torr by using a rotary vacuum pump and a diffusion vacuum pump, and then 0.23 cc of distilled water was filled therein as a working fluid. After that, the cases are sealed.

A heat source with length and width of 12 mm respectively is attached to a center of a region 10 mm spaced apart from one end of the flat plate heat transfer device manufactured as above, and a heatsink with length and width of 25 mm respectively and having a fan is attached to a center of a region 10 mm spaced apart from the other end. At this time, the heat source and the heatsink are attached to the same side. And then, a temperature of the heat source surface is measured while power is applied to the heat source with being increased from 1 W to 5 W.

According to the experimental results, though the maximum power of 5 W is applied, the temperature of the heat source does not exceed 47°C. Thus, it is understood that the flat plate heat transfer device according to the present invention may be adopted as a cooling heat transfer device for a relatively small electronic equipment with very small thickness and relatively low heat value.

INDUSTRIAL APPLICABILITY

According to the present invention, a conventional wick structure may be excluded by inserting a mesh, which gives a dispersion channel of a vapor and a flow channel of a liquid at the same time, in the flat case, thereby enabling to make an extremely thin flat plate heat transfer device. In addition, since the mesh firmly

supports the flat case, the flat plate heat transfer device is not transformed though an impact is exerted thereto while the device is manufactured or handled.

The present invention has been described in detail. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.